Claims

We claim:

1. A method for determining probabilities of states of a system represented by a model including a plurality of nodes connected by links, each node representing possible states of a corresponding part of the system, and each link representing statistical dependencies between possible states of related nodes, comprising:

grouping the plurality of nodes into arbitrary-sized clusters such that every node is included in at least one cluster and each link is completely contained in at least one cluster;

defining messages based on the arbitrary-sized clusters, each message having associated sets of source nodes and destination nodes and a value and a rule depending on other messages and selected links connecting the source nodes and destination nodes;

assigning initial values to the messages;

updating the value of each message using the associated rule; and

determining approximate probabilities of the states of the system from the messages when a termination condition is reached.

2. The method of claim 1 further comprising:

identifying nodes in intersections of clusters, and intersections of intersections of clusters as regions of nodes;

defining the messages based on the regions of nodes.

3. The method of claim 1 wherein the network has pair-wise statistical dependencies between nodes, and the overall probability of a particular assignment of states s at the nodes is:

$$P(s_1, s_2, \ldots s_N) = \frac{1}{Z} \prod_{i,j} \phi_{ij}(s_i, s_j) \prod_i \psi(s_i),$$

where the first product runs over all linked neighboring nodes, i and j, and wherein a ϕ compatibility matrix represents the statistical dependencies between the possible states s of the related nodes, and the ψ function for each node represents evidence that a particular node is in a particular state, and Z is a normalization constant to insure that the sum of the probabilities of all possible states of the system is equal to one.

4. The method of claim 1 wherein the initial values of the messages are random positive numbers.

5. The method of claim 1 wherein the initial values of the messages are all ones.

6. The method of claim 1 wherein the termination condition is a convergence the probabilities of the states of the system to a predetermined precision.

7. The method of claim 1 wherein the approximate probabilities are marginal probabilities.

8. The method of claim 1 wherein the approximate probabilities are maximum a posteriori probabilities.

9. The method of claim 1 wherein the states are discrete.

10. The method of claim 1 wherein the states are continuous.

11. The method of claim 1 wherein the network model includes closed loops.

12. The method of claim 1 wherein the nodes are arranged in a square lattice.

13. The method of claim 1 wherein the nodes are arranged in a triangular lattice.

14. The method of claim 1 wherein the nodes and links are a Markov network representation of an error-correcting code.

15. A method for determining probabilities of states of a system represented by a model including a plurality of nodes connected by links, each node representing possible states of a corresponding part of the system, and each link representing statistical dependencies between possible states of neighboring nodes, comprising:

grouping the plurality of nodes into arbitrary-sized clusters such that every node is included in at least one cluster, and each link is completed contained in at least one cluster;

identifying nodes in intersecting clusters, and intersections of intersecting clusters as regions, and intersections of regions as sub-regions;

discarding duplicate regions and sub-regions;

arranging the regions and sub-regions in a top-to-bottom hierarchy of intersections;

defining messages between regions and direct sub-regions directly connected in the hierarchy, each message having associated sets of source nodes and destination nodes and a value and a rule depending on other messages and selected links connecting the source nodes and destination nodes, the destination nodes being those nodes in the sub-region, and the source nodes being those nodes in the region and outside the sub-region;

assigning initial values to the messages;

updating the value of each message using the associated rule until a termination condition is reached;

determining approximate probabilities of the states of the system from the messages when a termination condition is reached.